The Dichotomus Horizon: proposal for a new biochronologic unit of the Giraudi Zone of the Upper Barremian of southeastern France, and considerations regarding the genus Imerites Rouchadzé (Ammonoidea, Gassendiceratinae)

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The Dichotomus Horizon: proposal for a new biochronologic unit of the Giraudi Zone of the Upper Barremian of southeastern France, and considerations regarding the genus *Imerites* ROUCHADZÉ (Ammonoidea, Gassendiceratinae)

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Abstract: Recent revisions of the genus *Imerites* ROUCHADZÉ make it possible to introduce a new biochronologic horizon to define more precisely the lower boundary of the Giraudi Zone: the Dichotomus Horizon. Using the concept of 'interval zone', this new horizon maintains the current lower boundary of the Giraudi Zone as accepted by authors, and thus contributes to the stabilization of the Barremian zonal system. This stabilization is also strengthened by abandonment of the use of "*Crioceras*" *cristatus* d'ORBIGNY (*nomen dubium*) that ought not be used as an index species in detriment of *Imerites giraudi* (KILIAN). The classification, origin, and intraspecific variation of the genus *Imerites* ROUCHADZÉ are examined.

Key Words: Tethyan realm; Upper Barremian; biostratigraphy; Interval zone; southeastern France; ammonites.

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Résumé : ***L'horizon à Dichotomus : proposition d'une nouvelle unité biochronologique de la zone à Giraudi du Barrémien supérieur du Sud-Est de la France, et considérations sur le genre* Imerites *ROUCHADZÉ (Ammonitina, Gassendiceratinae).-*** Les récentes révisions du genre *Imerites* ROUCHADZÉ permettent à présent d'introduire un nouvel horizon biochronologique afin de mieux définir la limite inférieure de la Zone à Giraudi : l'horizon à Dichotomus. Par l'application du concept de la zone d'intervalle, l'utilisation de cet horizon permet de conserver la limite inférieur actuelle de la zone à Giraudi telle qu'elle a été acceptée par les auteurs, et ainsi de contribuer à la stabilisation du schéma zonal du Barrémien. Cette stabilisation est aussi renforcée par l'abandon de l'usage de "*Crioceras*" *cristatus* d'ORBIGNY (*nomen dubium*) qui ne devrait pas être utilisé comme espèce indice au détriment de *Imerites giraudi* (KILIAN). La classification, l'origine et la variabilité intraspécifique du genre *Imerites* ROUCHADZÉ sont aussi discutées.

Mots-Clefs : Domaine téthysien ; Barrémien supérieur ; biostratigraphie ; zone d'intervalle ; Sud-Est de la France ; ammonites.

Introduction

After a period of instability, in recent years several studies have helped to fix the calibration of the Upper Barremian biostratigraphy of southeastern France that increased its value for practical use and increased the degree of its reproducibility by specialists working in discrete localities (REBOULET *et alii*, 2007, 2009 - see BERT *et alii*, 2008 for a historical account). It now includes the Vandenheckei, Sartousiana and Giraudi zones (Fig. 1), their limits based on faunal changes commonly associated with sequence boundaries developed in relation to

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eustasy (ARNAUD, 2005). In accord with the recommendations of the *IUGS Lower Cretaceous Ammonite Working Group, the KILIAN Group*, stabilization of the boundaries of these zones led to a preference for the use of interval zones rather than zones based on the range of a taxon. With good reason, for the boundaries of zones based on individual ranges are subject to repeated change in range limits caused by new finds or by tergiversation resulting from a revision of index taxa. Thus it seems preferable to choose stable and precise horizons for defining the base of zones (THIERRY, 1997). The introduction of several biochronological horizons (DELANOY, 1995, 1997, 1998; BERT *et alii*, 2008; BERT & DELANOY, 2009; BERT *et alii*, 2010) has contributed significantly to a refinement of the biostratigraphic pattern of the Tethyan Upper Barremian of southeastern France.

This work revises the definition of the lower boundary of the Giraudi Zone [index species: *Imerites giraudi* (KILIAN, 1888)] and is a manifestation of progress in the continuation of the revision of Upper Barremian biostratigraphy in southeastern France through emendation to the ammonite faunas which are a major element of its framework (here *Imerites* ROUCHADZÉ, 1933).

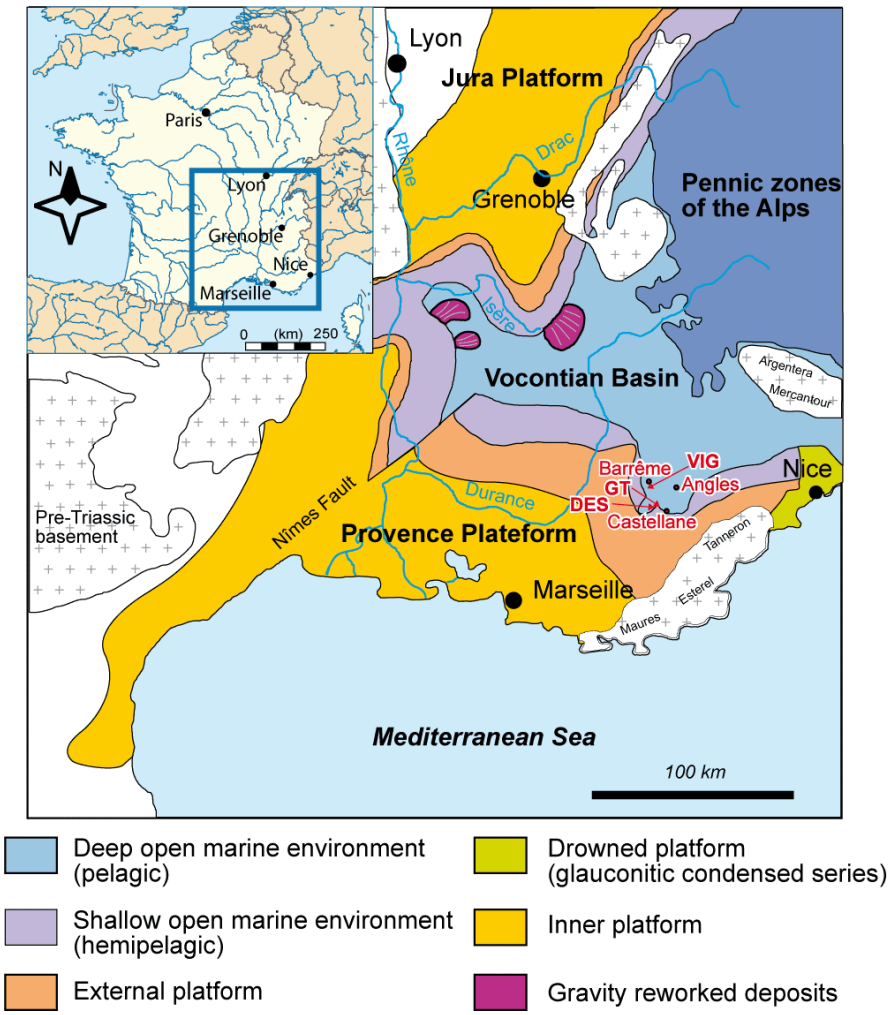
	Reboulet *et alii*, 2009			This work		
Stages	Zones	Sub-Zones	Horizons	Zones	Sub-Zones	Horizons
Upper Barremian	Giraudi	Waagenoides		Giraudi	Waagenoides	
		Sarasini			Sarasini	
			Puzosianum			Puzosianum
		Giraudi	Emerici		Giraudi	
						Emerici
			Giraudi			Giraudi
						Dichotomus
	Sartousiana	Feraudianus		Sartousiana	Feraudianus	Autrani
						Bersaci
						Magnini
						Feraudianus
		Provincialis			Provincialis	Casanovai
						Provincialis
		Sartousiana			Limentinus	Sartousiana
						Limentinus
	Vandenheckei	Barremense		Vandenheckei	Alpinum	Marchandi
						Breistrofferi
						Alpinum
		Vandenheckei			Vandenheckei	

Figure 1: Zonal scheme amended after BERT *et alii*, 2008, and REBOULET *et alii*, 2009. In red the Dichotomus Horizon (new). **Figure 1 :** Schéma zonal modifié d'après BERT *et alii*, 2008, et REBOULET *et alii*, 2009. En rouge, l'horizon à Dichotomus (nouveau).

The boundary between the Sartousiana and Giraudi zones, and the new Dichotomus Horizon

1- Geological setting

The Lower Cretaceous of southeastern France is marked by the evolution of a large intracratonic subsident area known as the Vocontian Basin (PAQUIER, 1900). The area of the historical Barremian stratotype (Angles-Barrême-Castellane area – Fig. 2), is in the southern part of the Vocontian Basin which is less affected by gravity remodelling and Alpine orogeny than its northern portion. The Barremian here is characterized by pelagic sediments, mainly alternation of marls and limestones in decimetric to metric beds. Given the relative continuity of deposits and the paleontological record, it is possible to track in considerable detail the succession and evolution of their ammonite faunas. Thus, following up on the work of DELANOY (1995, 1998), several sections of this area expose the boundary between the Sartousiana and the Giraudi zones well enough that they can be examined minutely: they are the Vignon section (VIG, Fig. 3), the Descouère section (DES, Fig. 4), and the Grande-Terre section (GT, Fig. 5).



◀ **Figure 2:** Barremian paleogeography of southeastern France and location of the area studied (from ARNAUD, 2005, amended). **Figure 2 :** Cadre paléogéographique du Sud-Est de la France et localisation du secteur d'étude (modifiée d'après ARNAUD, 2005).

2- The boundary between the Sartousiana and Giraudi zones in southeastern France

The base of the Giraudi Zone is characterized by an important phase of marine transgression (ARNAUD, 2005), marked lithologically by the "vire marneuse à *Heteroceras*" of authors. It is associated with a major faunal turnover (DELANOY, 1990, 1995, 1997, 1998; BERT *et alii*, 2008). This turnover is relatively progressive in strata at the top of the Feraudianus Subzone and at the base of the Giraudi Subzone. In fact, all change occurs between the lower part of the Feraudianus Subzone and the Emerici Horizon of the Giraudi Subzone (Fig. 1) where the Hemihoplitinae are progressively replaced quantitatively by the Heteroceratidae. At the base of the Feraudanus Subzone Hemihoplitinae are the major components of the ammonite fauna with a preponderance of the genus *Hemihoplites* SPATH. The Pulcheliidae and the Peirescinae are quite rare, as are the Gassendiceratinae (genera *Gassendiceras* BERT, DELANOY & BERSAC, 2006, and *Pseudoshasticrioceras* DELANOY, 1998) which become more numerous at the top of the Subzone (*i.e.* in the Bersaci and Autrani horizons). The genus *Heteroceras* d'ORBIGNY (with a turriculate morphology) is present at the upper limit of the Feraudianus Subzone (Autrani Horizon) but is extremely rare, for at this level and time it is only a very minor element of the ammonite fauna. In the lower portion of the Giraudi Subzone the situation is reversed: the Hemihoplitinae and the Pulcheliidae are gone and turriculate morphology dominates quantitatively, first briefly with *Imerites* (Gassendiceratinae), and later with *Heteroceras* which begin an increase in abundance at the base of the Giraudi Zone and proliferate accompanied by a morphological explosion in the Emerici Horizon (DELANOY, 1990, 1995, 1997, 1998; DELANOY & EBBO, 2000; DELANOY & BERT, 2006).

Above the Autrani Horizon (Feraudianus Subzone, Sartousiana Zone, Fig. 1), the appearance of the genus *Imerites* ROUCHADZÉ is currently accepted by authors as the valid marker of the lower limit of the Giraudi Zone (see historical account in KAKABADZE, 1989; HOEDEMAEKER & BULOT, 1990; DELANOY, 1990, 1995, 1998; REBOULET *et alii*, 2006, 2007, 2009; BERT *et alii*, 2008). Revisions of this genus by DELANOY (1998) and BERT *et alii* (2009), improved understanding of the stratigraphic distribution of the species of *Imerites*. Their development over time is coincident with the evolutionary framework of the last Gassendiceratinae BERT, DELANOY & BERSAC, 2006. So in the succession

Imerites dichotomus ERISTAVI, 1955 appears before *Imerites giraudi* (KILIAN, 1888). The use of an interval zone allows a redefinition of the lower boundary of the Giraudi Zone without change of level by use of the new Dichotomus Horizon (defined below). This usage preserves the integrity and stability of Barremian zonation (BERT *et alii*, 2008). There is no need to move the lower limit of the Giraudi Zone upward to make it coincident with the appearance of its index species, or to rename the Giraudi Zone as the Dichotomus Zone, because *I. dichotomus* ERISTAVI is the first species of *Imerites* of which the appearance coincides with the accepted definition of the lower limit of the Giraudi Zone. In any event, any shift in level would dissociate the base of the Giraudi Zone from the faunal turnover and the sequence boundary with which it is coincident (ARNAUD, 2005); application either of these options would change the level of the base of the zone and return to the instability that has long characterized Barremian zonation and should cease.

3- The Dichotomus Horizon (*new*)

In France *Imerites dichotomus* ERISTAVI has a very limited and precise stratigraphic position. By anagenesis (BERT *et alii*, 2009) it is the successor of the index species *Pseudoshasticrioceras autrani* (DELANOY), and the ancestor of the index species *Imerites giraudi* (KILIAN). In the stratotype area (Vocontian Basin, southeastern France – Fig. 2) its appearance in the stratigraphic succession is in agreement with its biologic relationships. These facts, and the need for the establishment of a high resolution biostratigraphy for the whole of the Barremian (REBOULET *et alii*, 2006; REBOULET *et alii*, 2007; BERT *et alii*, 2008; REBOULET *et alii*, 2009), has impelled us to propose *Imerites dichotomus* ERISTAVI as a new biostratigraphic marker in the Vocontian Basin. This species occurs in strata immediately above the major beds of the Autrani Horizon at the top of the Feraudianus Subzone (Sartousiana Zone), and immediately precedes those of the Giraudi Horizon where *Imerites giraudi* (KILIAN) occurs (Figs. 3 - 4 - 5).

Index species: *Imerites dichotomus* ERISTAVI, recently revised by BERT *et alii* (2009).

Status: This horizon is defined by the first appearance of its index species (bed No. 436 in the Vignon [VIG] section, Fig. 3), and its upper limit is currently set at the base of the Giraudi Horizon (bed No. 439 in the VIG section) with the first appearance of *Imerites giraudi* (KILIAN). The Dichotomus Horizon is also present in the sections near La Baume (Castellane area): beds 151 to 152 in the Descouère section (DES, Fig. 4), and bed 679 in the Grande-Terre section (GT, Fig. 5) [see also DELANOY, 1995, 1998].

Paleobiogeographic distribution: *Imerites dichotomus* ERISTAVI is present in southeastern France but also in Spain (oral communication of COMPANY, see DELANOY, 1998, p. 207), Bulgaria, Romania and Georgia (see BERT *et alii*, 2009), a distribution that augers an extensive application of the Dichotomus Horizon.

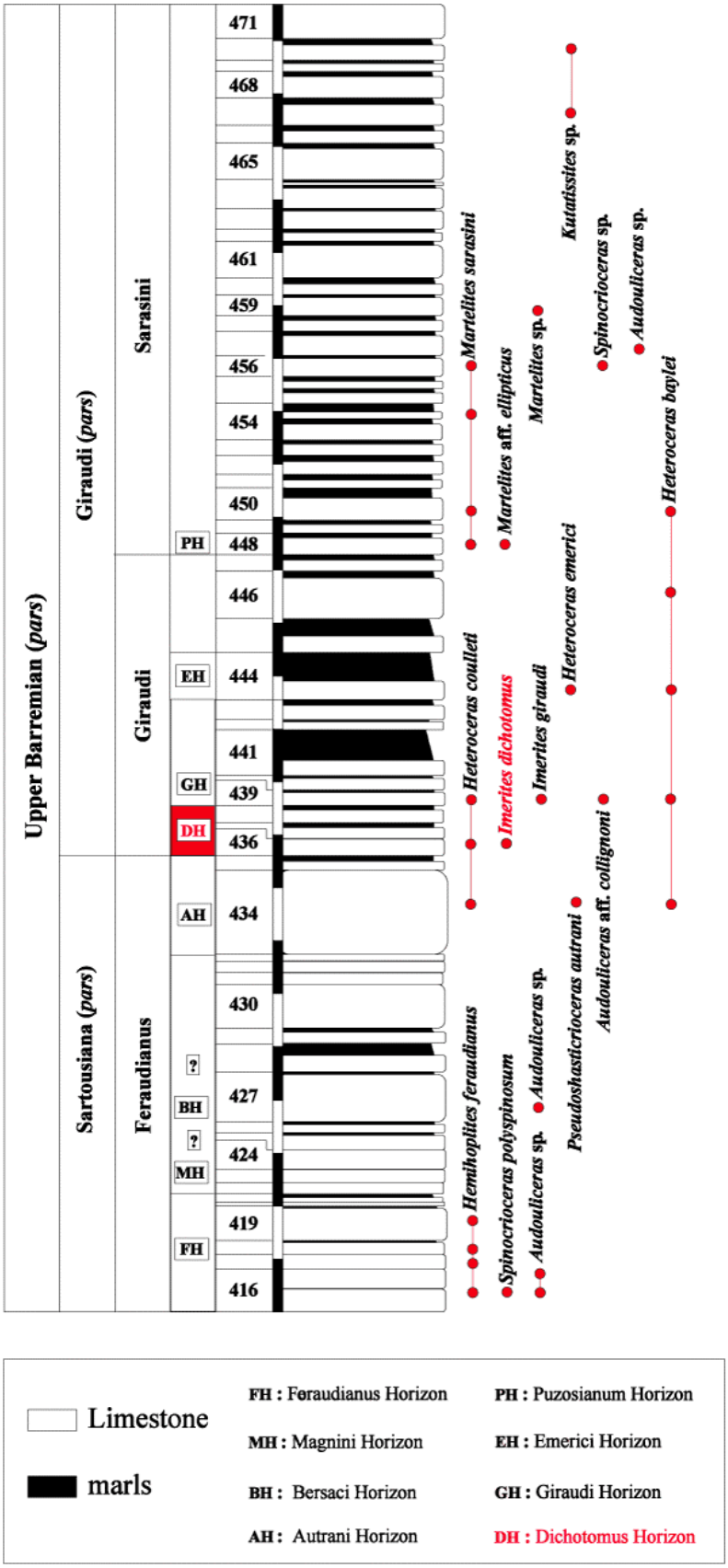
Faunal assemblages: The index species is generally fairly well represented in the French' sections. It is associated with (see DELANOY, 1995, 1998; BERT *et alii*, 2008): *Macroscaphites yvani* (PUZOS) macro- and microconchs, *Acantholytoceras pseudoaudouli* (THOMEL) macro- and microconchs, *Jaubertites collignoni* SARKAR, *Protetragonites crebrisulcatus* (UHLIG), *Eulytoceras phestus* (MATHERON), *Silesites seranonis* (d'ORBIGNY), *Melchiorites melchioris* (TIETZE), *Barremites difficilis* (d'ORBIGNY), *Barremites strettostoma* (UHLIG), *Phyloceras ponticuli* (ROUSSEAU), and with *Heteroceras coulleti* DELANOY, *Heteroceras baylei* REYNES and *Spinocrioceras trachyomphalus* (UHLIG).

Considerations regarding the genus *Imerites* ROUCHADZÉ, 1933

1- Remarks on the classification and origin of *Imerites*

The genus *Imerites* ROUCHADZÉ has traditionally been classified as a Heteroceratidae, but it is now recognized as a representative of the family Hemihoplitidae (see BERT *et alii*, 2009 for an historical account) despite the presence of a turricone in the juvenile part of the shell (helicoidal coiling). SARKAR was the first to classify *Imerites* (his *Escragnolleites*) in the Hemihoplitidae (1955, p. 24) because it has a hemihoplitid ancestor (1955, p. 18, 22), although KILIAN (1907-1913) saw "some similarities" between *Heteroceras giraudi* (=*Imerites*) and some Hemihoplitidae [=*Ancyloceras (Crioceras) heberti* in KILIAN's time]. It has been recognized for a long time that helicoidal coiling is not restricted to the Heteroceratidae. Indeed, KILIAN (1888, 1889) was the first to restrict the genus *Heteroceras* d'ORBIGNY only to those Barremian taxa that have a turricone. But d'ORBIGNY classified one Senonian species (1851, p. 222) as a heteroceratid, and MEEK (1876) included helicoidal forms from the Upper Cretaceous of the United States of America (Nostoceratidae) in that group, thus indicating broader criteria for their classifications. This type of coiling is known to have developed repeatedly in the evolutionary history of the ammonoids (*e.g.* Triassic *Cochloceras*; some Bajocian *Spiroceras*; Uppermost Barremian *Kutatissites*; some Lower Cretaceous Leptoceratoidae; Albian *Mariella*, *Turrilitoides*, *Helicoceras* or *Pseudhelicoceras*; Cenomanian *Turrilites*, *Hypoturrilites*, *Mesoturrilites* and *Ostlingoceras*; *Axonoceras*, *Jouaniceras*, *Anaklinoceras* and some other Nostoceratidae from the Upper Cretaceous, *etc*. – see ARKELL *et alii*, 1957 and WRIGHT *et alii*, 1996). But these authors did not remark a connection between these homeomorphs and the Heteroceratidae. More recently, KAKABADZE (2004, p.

21) made the following observation about certain genera with helicoidal coiling and the absence of any relationship to the Heteroceratidae: "the similarity in the mode of coiling (helicoidal, planispiral or helicoidal, planospiral and uncoiled) is not important for identifying the systematic position as to family". And DELANOY (1998, p. 184) said about *Imerites* that "the presence of the turricone would be only the expression of a homeomorphism that affects the early developments of these forms" (translation pars).



◀ **Figure 3:** Distribution of the ammonites in the Vignon (VIG) section *pars* (Barrême area, Alpes-de-Haute-Provence).
Figure 3 : Répartition des faunes d'ammonites dans la coupe du Vignon (VIG) *pars* (secteur de Barrême, Alpes-de-Haute-Provence).

BERT *et alii* (2009) were the first to distinguish and define evolutionary processes in the origin and development of species in the genus *Imerites* of the Hemihoplitidae. Their work involved study of an evolved "*Pseudoshasticrioceras*" ornament in *Imerites dichotomus* ERISTAVI (see BERT *et alii*, 2006). In that stage of development weaker peri-ventral tubercules demonstrate that *Imerites* is a direct descendant of the genus *Pseudoshasticrioceras* DELANOY (Gassendiceratinae BERT, DELANOY & BERSAC). This taxonomic distinction between genera of the same lineage is based on the early appearance of a turricone during the growth of *Imerites* (BERT *et alii* 2009).

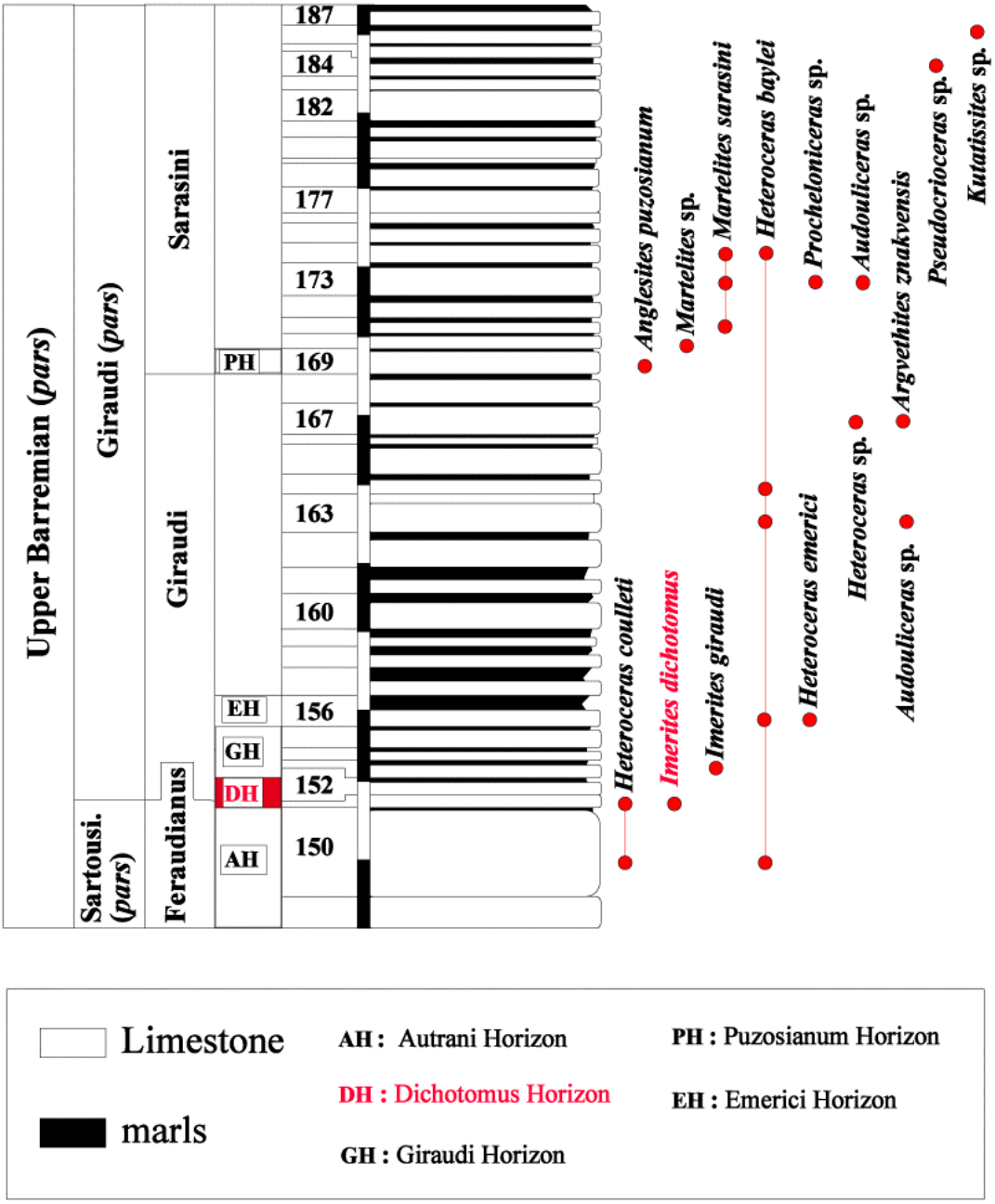


Figure 4: Distribution of the ammonites in the Descouère (DES) section *pars* (La Baume in the Castellane area, Alpes-de-Haute-Provence).
Figure 4 : Répartition des faunes d'ammonites dans la coupe du Descouère (DES) *pars* (La Baume, secteur de Castellane, Alpes-de-Haute-Provence).

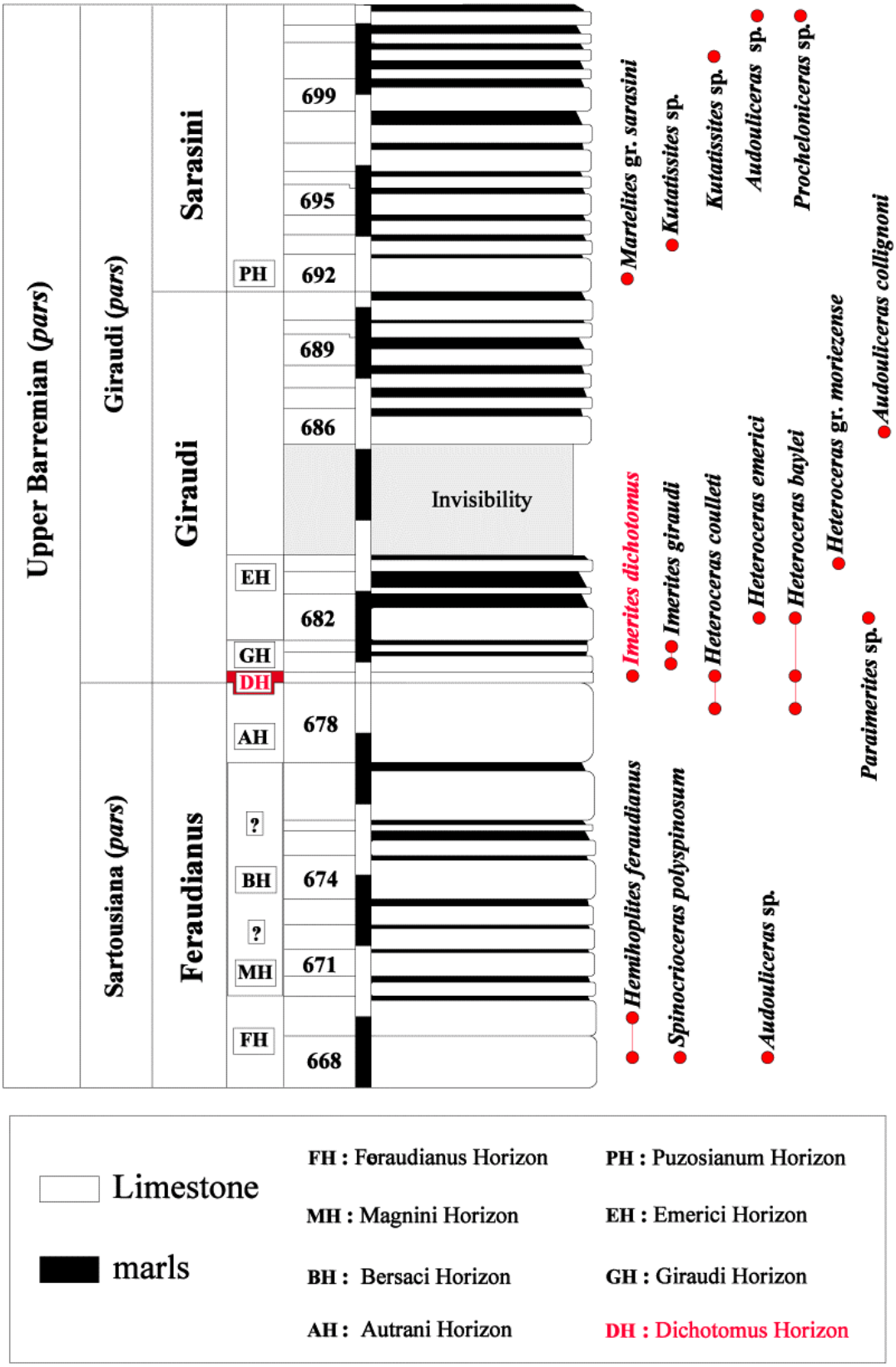


Figure 5: Distribution of the ammonites in the Grande-Terre (GT) section *pars* (La Baume in the Castellane area, Alpes-de-Haute-Provence).
Figure 5 : Répartition des faunes d'ammonites dans la coupe de la Grande-Terre (GT) *pars* (La Baume, secteur de Castellane, Alpes-de-Haute-Provence).

We welcome acceptance of the genus *Imerites* into the Gassendiceratinae but we do not agree with the broader generic limits proposed for *Imerites* by VERMEULEN & LEPINAY (2010, p. 18, 20). Their diagnosis includes some non-turriculate Hemihoplitidae, which would cause problems that preclude its acceptance:

1. the large range of variation in morphology and ornament proposed for their *Imerites* by these authors requires a redefinition of this genus to include criteria much broader in scope than those commonly acceptable to specialists. Their proposal widely depasses the intent of the author of the genus *Imerites* ROUCHADZÉ and that of subsequent workers. This new definition would produce a genus-group taxon which would greatly lessen the precision of identification and make correlation with previous work difficult. So nomenclatural stability would be threatened and Upper Barremian biostratigraphy again subject to revision because of confusion regarding the stratigraphic ranges of the species of the genus *Imerites* ROUCHADZÉ;
2. the ornamental and morphological characteristics specified in the emended diagnosis of VERMEULEN & LEPINAY, would include in their genus *Imerites* species of Hemihoplitinae currently assigned to other genera, although they lack any phyletic link to them. So *Imerites* in VERMEULEN & LEPINAY'S usage, might well include the taxa *Hemihoplites* SPATH, *Camereiceras* DELANOY, *Pachyhemihoplites* DELANOY or *Ancylezeiceras* VERMEULEN.

This problem is particularly evident in the taxon "*I.*" *stephaniae* VERMEULEN & LEPINAY, 2010 (found in the Provincialis Subzone: One subzone separates it from the appearance of the first *Imerites s. str.)* that they attribute to the genus *Imerites* ROUCHADZÉ, but do not compare it with contemporary Hemihoplitids. "*I.*" *stephaniae* VERMEULEN & LEPINAY is a fragmentary specimen (VERMEULEN & LEPINAY, 2010, p. 21, Pl. 1, fig. 7) particularly close in aspect to contemporary *Hemihoplites* of the group *H. casanovai* DELANOY (=*H. intermedius* VERMEULEN - currently under study).

2- The case of *"Crioceras"* *cristatus* d'ORBIGNY, 1842

As DELANOY (in GAUTHIER *et alii*, 2006, p. 138-139), maintained "*Crioceras*" *cristatus* d'ORBIGNY should be considered synonymous with *Imerites giraudi* (KILIAN) and according to the principle of priority of the *International Code of Zoological Nomenclature* (ICZN - Art. 23.1) has seniority. Consequently, for VERMEULEN & LEPINAY (2010, p. 20) another amendment of Barremian zonation would be necessary: renaming the Giraudi Zone as the Cristatus Zone [note that this is not obligatory, for the *International Stratigraphic Guide* (SALVADOR, 1994, p. 67) states that "if it is desirable to continue use of a taxonomic term which is no longer valid, the term should be in quotation marks"].

However new data obtained in the recent revision of *Imerites* by BERT *et alii* (2009, p. 32-33) found the syntypes of "*Crioceras*" *cristatus* d'ORBIGNY of the d'ORBIGNY's collection are too fragmented to be identified at a specific level, and the fragments may not be of just one specimen but may even represent more than one species. These facts render this taxon unusable and a *nomen dubium*. Moreover, d'ORBIGNY's (1842, Pl. 115, figs. 4-8) original illustrations are probably a synthetic compilations (*i.e.* a picture based on several different but fragmentary specimens assembled and restored to appear as if they were a single specimen). They were recognized as such by KILIAN (1888, 1889). In the original illustration the turricone is replaced by planispiral whorls for the stages of growth of the actual syntypes (particularly fragmented) when compared to the original picture make this obvious. So the rehabilitation of "*Crioceras*" *cristatus* d'ORBIGNY, 1842, to replace *Imerites giraudi* (KILIAN, 1888), a long-used, well defined taxon (recognized by many authors), is not desirable. Moreover, the purpose of the ICZN principle of priority is explained by Article 23.2 which states very explicitly that it must foster nomenclatural stability: "it is not intended to be used to upset a long-accepted name in its accustomed meaning by the introduction of a name that is its senior synonym or homonym, or through an action taken following the discovery of a prior and hitherto unrecognized nomenclatural act"; *a fortiori* when the older name is based on a synthetic compilations and can be considered as a *nomen dubium* because it differs from characteristics found in its syntypes. On the other hand, the proposal of invalidation by VERMEULEN & LEPINAY (2010, p. 17-18) of the d'ORBIGNY's syntypes in favour to a more complete neotype (not among the syntypes) does not comply with the provisions of the ICZN (Art. 75, and in particular, § 75.3.4) and therefore cannot be implemented. At most it might be possible to designate one of the original syntypes as a lectotype (n°5405-1 of the d'ORBIGNY's collection), but the basic problem remains unchanged...

Whatever the nomenclatural possibilities mentioned earlier (DELANOY in GAUTHIER *et alii*, 2006, p. 139), *Imerites giraudi* (KILIAN) is the type-species of the genus *Imerites* ROUCHADZÉ and we strongly recommend "*Crioceras*" *cristatus* d'ORBIGNY be considered invalid.

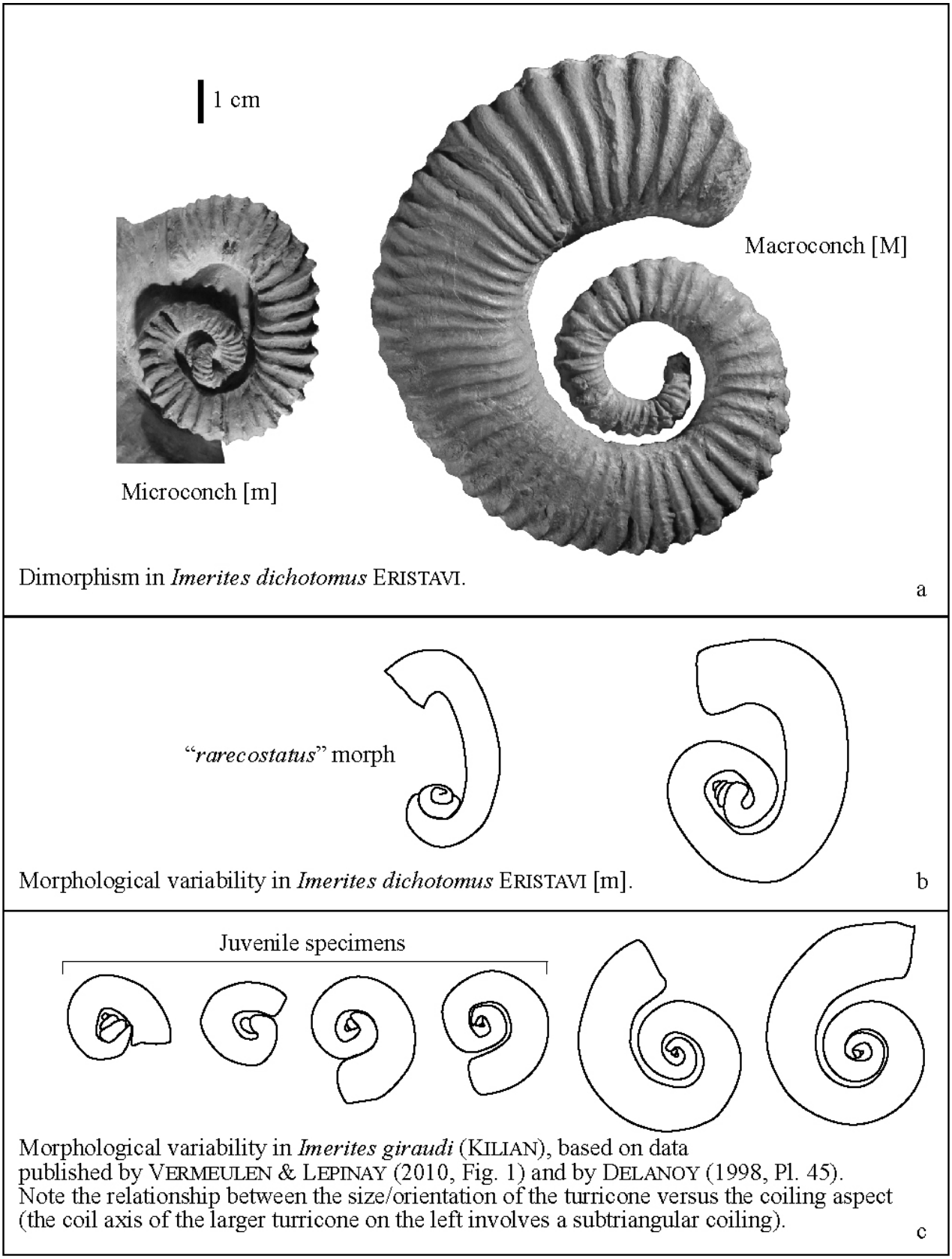


Figure 6: Dimorphism and variability in shell morphology in *Imerites*.
Figure 6 : Dimorphisme et variabilité morphologique de la coquille chez *Imerites*.

3 - Intraspecific variability in *Imerites* and mechanical constraints associated with the presence of turricone

Intraspecific variability in species of *Imerites* involves ornamentation, some dimensional parameters of the shell and the size and orientation of the turricone (Fig. 6c). The relationship of turricone size and placement to changes in shell morphology has been studied by DELANOY (1998, p. 53) for the genus *Heteroceras* and was illustrated by KAKABADZE (2004, Fig. 10) for the *Kutatissites*. In *Imerites*, the phenomenon is the same: a larger turricone generally is accompanied by a less regular or triangular coiling before normal involution resumes. However, contrary to the views of VERMEULEN & LEPINAY (2010) these purely mechanical constraints are not comparable with the dimorphic differentiation in *Imerites dichotomus* ERISTAVI where tripartite adult microconch [m] are associated with large planospiral adult macroconch [M] (see BERT *et alii*, 2009, Pl. 2, fig. 2 *versus* Pl. 1, fig. 1 – Fig. 6a) for several reasons:

1. The dimorphs of the adult stages of *I. dichotomum* ERISTAVI are very different and there are, to our knowledge, no intermediaries (Fig. 6a);
2. The presence of such intermediaries was assumed by VERMEULEN & LEPINAY (2010) because of the existence of specimens with a triangular coil ("*I. cristatus favrei* morphotype" of Pl. 1, figs. 5-6). These specimens of which the whorl "may represent a draft shaft" (p. 18) are too small in size and incomplete. They are only juvenile whorls with triangular coiling that wraps the turricone, but lack an uncoiling of the outer whorls to form a shaft (Fig. 6c). Only the specimens figured Pl. 1, figs. 1-2 of their publication may be adult, but they are crioconic with no shaft. Consequently, no adult specimen with a morphology intermediate between those of micro- and macroconchs are known;
3. The tripartite *Imerites raricostatus* (KAKABADZE) has a well expressed ornamental stage with fibular ribs (the type specimen is refigured in KOTETISHVILI *et alii*, 2005, Pl. 87, fig. 2) and its ontogenic sequence is very similar to the tripartite specimen figured in BERT *et alii* (2009, Pl. 2, fig. 2 – Fig. 6a). Therefore *I. raricostatus* (KAKABADZE) is a microconch of *I. dichotomus* ERISTAVI and not a morphotype of *I. giraudi* (KILIAN) (VERMEULEN & LEPINAY, 2010). Complete adult microconch specimens of *I. dichotomus* ERISTAVI seem quite rare, but adult macroconchs are also few. The adult form of the macroconch was unknown prior to the recent revision by BERT *et alii* (2009). Juvenile or fragmentary specimens of this species that are difficult to place because of uncertainty regarding which dimorph they represent are relatively common;
4. Variability in the size of the turricone *versus* that of the morphology of the shell is well expressed in the macroconchs of *Imerites dichotomus* ERISTAVI, just as it is in *Imerites giraudi* (KILIAN) (Fig. 6c). This is the same in the microconchs of *I. dichotomus* (Fig. 6b): the type specimen of *I. rarecostatus* (=*I. dichotomus* [m]) has a large turricone and minute coil, whereas the specimen figured Pl. 2, fig. 2 (in BERT *et alii*, 2009) has a well-developed coil and a relatively small turricone;
5. The specimens of *I. giraudi* (=*I. cristatus* in VERMEULEN & LEPINAY, 2010) cannot be used to suggest the absence of dimorphism in *I. dichotomus*, since the tripartite coiling of the microconchs is currently recognized with certainty only in *I. dichotomus*.

Conclusions

Recent revisions of the genus *Imerites* ROUCHADZÉ provide an increased understanding of its variability and its evolution, so now permit the introduction of a new biochronologic horizon, the Dichotomus Horizon (Fig. 1), to define the lower boundary of the Giraudi Zone more precisely. Using the interval zone concept, the addition of this horizon maintains the current lower boundary of the Giraudi Zone as accepted by authors (the appearance of the genus *Imerites*), and thus contributes to the stabilization of the Barremian zonal scheme. This stabilization is also strengthened by the abandonment of "*Crioceras*" *cristatus* d'ORBIGNY (*nomen dubium*) that ought not be used as index species instead of *Imerites giraudi* (KILIAN). Following THIERRY (1997), in general (as it is for the Barremian) it is preferable to use interval zones rather than the stratigraphic range of any one taxon for example, to avoid constant changes of boundaries that discoveries and systematic reviews of index taxa might impose, thus threatening the stability of the zonation. The introduction of a new biochronologic horizon increases the precision of the biostratigraphic zonation of the Barremian stage in southeastern France which is a requirement for the study in detail of the evolution of ammonites and their populations.

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